# Chapter 5
# Analyzing the Landscape and Its Wetlands

## 5.1 Introduction

Chapter 4 outlined the four basic steps proposed as the framework for protecting and managing wetlands. The first step in the framework is to analyze the landscape and its wetlands (Figure 5-1). This chapter describes how the landscape and wetlands might be analyzed, and it provides the basic questions that should be answered to complete such an analysis. The questions should enable local governments to develop their own methods for landscape analysis if desired.

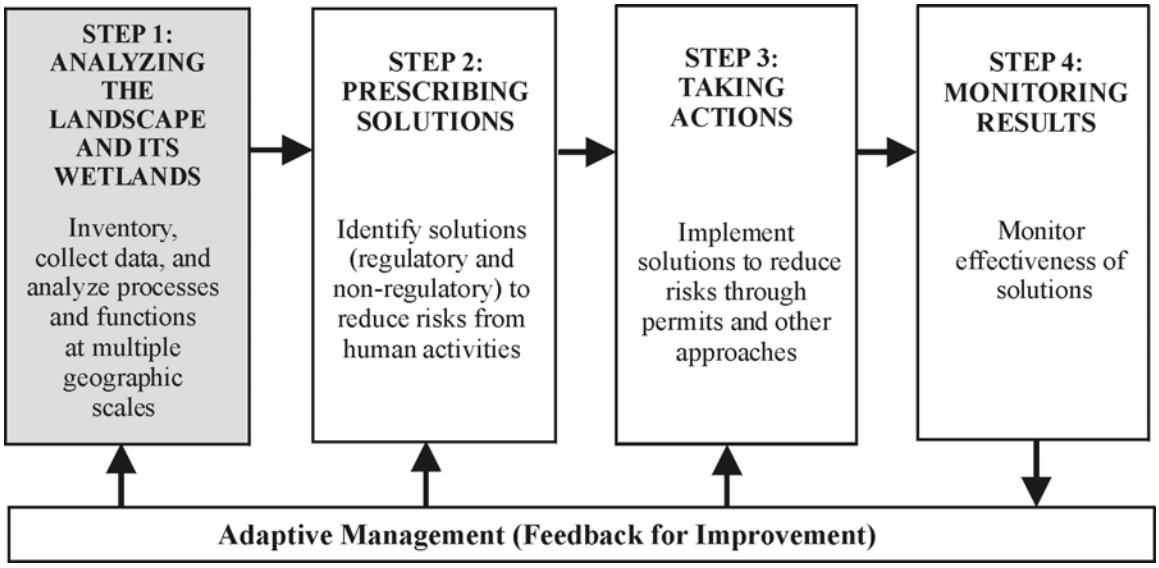


**Figure 5-1. Step 1 in the process of protecting and managing wetlands is to analyze wetland resources (shaded box). Step 1 is discussed in detail in this chapter.**

The questions discussed in this chapter are derived from the work on environmental processes in the Pacific Northwest done by Bedford (1996, 1999), Booth (1991), Brinson (1993), Gersib (2001), Naiman et al. (1992, 1993, 1997), Horner (1986), Horner et al. (1996), LaBaugh et al. (1987), Beechie and Bolton (1999), Stanley and Grigsby (2003), Winter (1983, 1986, 1988, 1989, 1992), and Ziemer and Lisle (1998). Any method or methods that provide answers to these questions can be used.

**Why do we analyze more than just wetlands?**

The synthesis of current science (Chapter 2 in Volume 1) indicates that the functions performed by wetlands are controlled by processes that may occur in other parts of the landscape as well as at the site of the wetland itself. To protect and manage the functions and values of wetlands, we need to understand how changes to these wider scale processes can impact wetlands.

## Where to Find Supporting Information in Appendices

The following appendices provide additional information and details to help the reader more fully understand the landscape analysis described in this chapter:

**Appendix 5-A** identifies some of the existing sources of data that can be used to answer the questions when analyzing the landscape and its wetlands.

**Appendix 5-B** summarizes numerous literature sources that provide more detail on how to analyze environmental processes at the contributing landscape, management area, and site scales.

**Appendix 5-C** illustrates two examples of how the analytical process discussed in this chapter is being used in two areas of Washington State to characterize and analyze existing processes and functions, identify changes in functions, and identify measures for restoration.

**A method for analyzing the landscape and its wetlands that uses existing data is being developed**

As noted in Chapter 1 of this document, some local governments will be interested in a method that Ecology is developing to analyze the landscape and its wetlands. The method uses existing data available through various agencies, and is designed to provide the information needed to make land use decisions throughout the four-step framework described in Volume 2. The method being developed by Ecology is illustrated by examples of landscape analysis that are presented in Appendix 5-C. Ecology's method has been applied in several jurisdictions and is being improved with each application. The current methods being developed by Ecology do not address wildlife corridors. This gap will be addressed next year as the Departments of Fish and Wildlife and Ecology work together to better include wildlife in the landscape analysis. Ecology would like to work with local governments to apply this method in other jurisdictions and further improve it as funding and time are available.

The questions that need to be addressed in the analysis of the landscape and its wetlands apply regardless of the methods used to analyze the resource. The method being developed by Ecology is only one way they can be answered. Other methods that may provide similar information are summarized in Appendix 5-B.

The next section of this chapter (Section 5.2) summarizes the importance of the interaction between landscape processes and wetland functions because this information may not be common knowledge for some planners. Section 5.3 provides background on the goals of landscape analysis, again because this is a new approach in protecting and managing wetlands. Section 5.4 describes the basic questions that should be answered when analyzing the contributing landscape and management area to assist with decision-making. Section 5.5 then addresses analysis at the scale of individual wetlands.

## 5.2 Landscape Processes and Their Influence on Wetlands and Their Functions

Chapter 2 in Volume 1 describes how landscape processes interact with climate, topography, and surface geology to determine the biological, physical, and chemical characteristics (structure) of wetlands and other aquatic resources (e.g., the soils, plant species, configuration of inlets and outlets, etc.). The structure of wetlands then has a direct influence on the type and level of functioning within wetlands. The sequence, however, does not go only in one direction. Some wetland functions can in turn influence the structure of other wetlands and landscape processes (e.g., when wetlands provide habitat for beavers; see diagram in Figure 5-2).

In the Pacific Northwest, the landscape processes that are often associated with wetland functions include:

- The movement of **water** (surface and subsurface) through the contributing landscape and at the wetland site itself;
- The movement of **sediment**;
- The movement of **nutrients** and other chemicals (salts, toxic contaminants);
- The movement of **energy** in the form of carbon (plant and animal material);
- The movement and actions of **wildlife**; and
- The dispersal of **plants.**

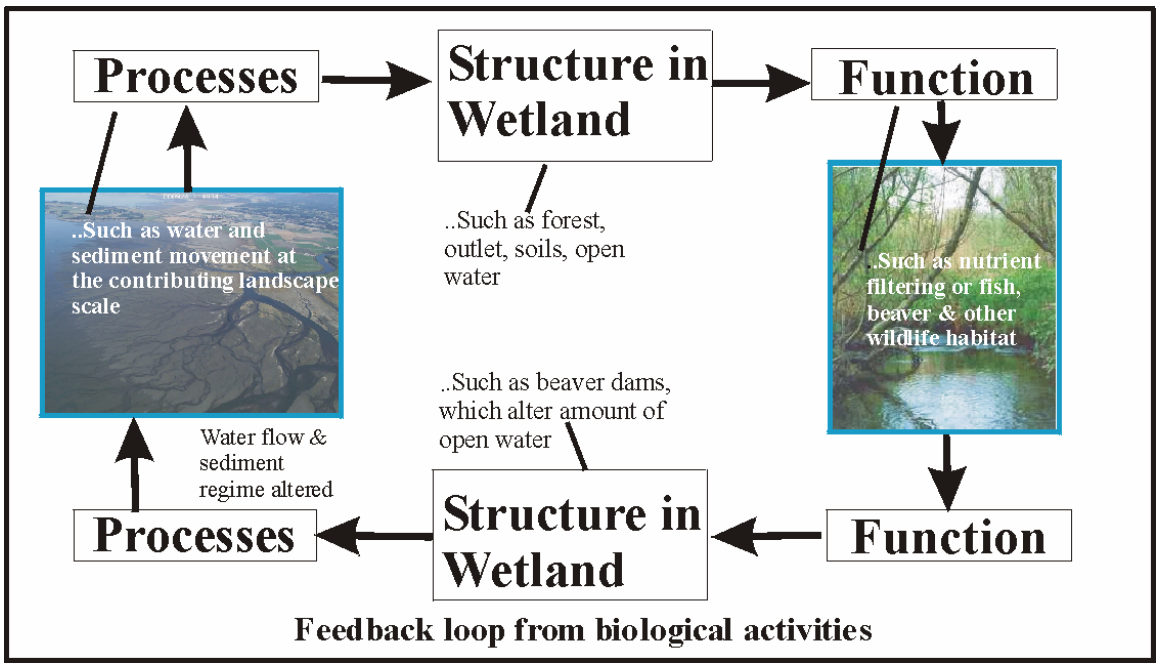


**Figure 5-2. Wetlands and their functions are an expression of landscape processes. Wetland functions can in turn modify the landscape processes.**

As an example, a wetland may function to support a rich food web in the aquatic ecosystems downstream by exporting large quantities of plant material. In order to provide this function, the wetland needs to have the following:

- Water with adequate nutrients coming into the wetland,
- Good exposure to sunlight, and
- A way for the plant material to pass from the wetland into downstream aquatic ecosystems.

The major processes that control the export of food that supports the aquatic food web are the movement of water to and from the wetland, and the movement of nutrients into and within the wetland. Thus, human alterations in the movement of water and nutrients into the wetland from the contributing landscape may change how the wetland supports the food web downstream.

## 5.3 Goals and Objectives of Analyzing the Landscape (Landscape Analysis)

The primary goal of a landscape analysis is to develop an understanding of where landscape processes occur and where they are particularly sensitive to human disturbances. As mentioned previously, changes to landscape processes will often result in changes to the functions in wetlands. An understanding of the geographic locations

where processes are most sensitive to change is needed to identify appropriate and effective solutions for protecting wetlands and their functions (these solutions are then developed in Step 2 of the framework). Understanding environmental processes in the landscape is basic to planning how humans should use the land in the future, where they should preserve it, or how they might restore it. For example, landscape analysis can support comprehensive planning because it provides a basis for understanding the future impacts of different zoning configurations and development scenarios. The following objectives help achieve this goal:

- Identifying which parts of the landscape provide essential environmental processes (landscape processes);
- Identifying the range of disturbances that affect landscape processes, and whether they are caused by human activities or natural disturbances;
- Identifying which geographic areas are most susceptible to these disturbances, and therefore pose environmental constraints to land uses in these settings;
- Determining how the landscape processes and the geographic areas that provide these processes influence wetlands and their functions.

By meeting these objectives it is possible to identify solutions (e.g., zoning designations restoration plans) to protect and restore or maintain landscape processes as well as wetlands and their functions. Understanding the environmental constraints on geographic areas is critical to planning for human activities that minimize ongoing or future impacts to wetlands. The questions posed in the following section can be used to meet these objectives.

These objectives apply to analyzing both the contributing landscape and the management area. Landscape processes are not geographically constrained by political boundaries. The reason for presenting a framework that separates the contributing landscape into two geographic units (the management area and the contributing landscape outside the management area) is to simplify the task of managing and protecting the wetland resources. Landscape processes and wetlands that occur within a jurisdictional boundary can be protected and managed by that jurisdiction. Protection outside the jurisdictional boundary will require a cooperative effort by several jurisdictions.

## 5.4 Questions that Can Be Used to Guide an Analysis of the Contributing Landscape and the Management Area

The questions listed below can be used to guide an analysis of the landscape and are phrased so the answers can be used to meet the goals and objectives described above. Each question is discussed in detail in the subsections that follow.

The questions that direct the analysis are similar for both the contributing landscape and the management area. The difference in the analysis for these two geographic scales is more an issue of resolution than a different approach. If the management area is smaller than the contributing landscape, the analysis of the management area can make use of more detailed information. Local jurisdictions can then develop more detailed plans and be provided a better assurance that the risks to their wetlands are minimized. The same tools and methods, however, can be used at either geographic scale.

- **Question 1.** What are the landscape processes in the contributing landscape and where were they located geographically before 1800 (pre-European colonization)?
- **Question 2.** What are the relationships between these original landscape processes and wetlands and their functions in the management area?
- **Question 3.** What alterations to landscape processes have occurred, and how have these changes affected wetlands and their functions?
- **Question 4.** What geographic areas are currently important for maintaining landscape processes and can be impacted by future activities and growth?
- **Question 5.** What potential measures are needed to protect and restore landscape processes in order to protect and restore wetlands and their functions?

These questions are focused on analyzing the contributing landscape and the management area (see the review of geographic scales below). This is the analysis that should be done by local jurisdictions prior to developing comprehensive plans, critical areas ordinances, and shoreline master programs. Although each question is directed toward wetlands and their functions, some of the landscape processes analyzed through answering these questions involve other aquatic resources and critical areas.

## Question 1. What are the landscape processes in the contributing landscape and where were they located geographically before 1800 (pre-European colonization)?

The focus of this question is on processes that affect wetlands in the management area, but it can apply to all landscape processes in the contributing landscape because they are important factors for all critical areas. Understanding the landscape processes and functions that were present in the absence of human disturbances defines the baseline conditions against which changes can be compared. In addition, it helps to identify the aspects of processes that are essential to maintaining current functions of wetlands.

### Understanding the environmental processes in the absence of human disturbance is important even if recreating the "undisturbed conditions" is not a goal of the planning process.

This question can be answered by identifying and mapping the landscape processes that support or maintain wetlands and their functions. In general, these processes will fall into the following categories: the movement of water, sediment, nutrients, energy, and

wildlife, as well as physical, chemical, and biological interactions that can occur at the watershed and subbasin scale. To identify these processes, the jurisdiction will need to consider the historic condition and location of the following:

- Surface water drainage patterns – how surface water reaches the wetlands (e.g., areas contributing water to the wetlands including streams, culverts, stormwater outfalls, and sheet flow)
- Groundwater flow paths – where groundwater is recharged and discharged
- Sediment inputs and flow paths – sediment sources, sediment depositional areas, and ways that sediment moves through the landscape to the wetlands
- Nutrient inputs and flow paths – likely sources of nutrient inputs, areas where nutrients would be removed, and pathways for nutrients reaching the wetlands
- Corridors along which wildlife moves and plants are dispersed

Sources for this information include soils maps, aquifer recharge maps, stream inventories, topographic maps, resource/habitat maps from state and federal agencies, zoning maps of active agricultural lands, or even environmental documents such as environmental impact statements. Note that some of these landscape processes may occur at a scale much larger than the extent of the historic wetlands and may extend throughout the contributing landscape.

### Question 2. What are the relationships between these original landscape processes and wetlands and their functions in the management area?

Answering this question requires analyzing the connections between the location of landscape processes and existing and historic wetland resources. The most important process to consider is where on the landscape water surfaces, or where surface water is slowed down enough to be ponded. Generally wetlands will form in these locations. For example, extensive peat deposits at the base of a slope where groundwater surfaces would indicate a probable location of wetlands. Topographic depressions in a floodplain would indicate locations where floodwaters can be stored and where wetlands also often occur.

The connections between wetlands and landscape processes are very specific to the topographic, geologic, and climatic conditions of an area. In the absence of a geographically specific method such as that being developed by Ecology, local experts will need to be consulted to develop an understanding of the links between wetlands and landscape processes.

## Question 3. What alterations to landscape processes have occurred, and how have these changes affected wetlands and their functions?

Answering this question will require understanding where the following alterations have occurred:

- Changes to water flow. For example, areas where:
  - Surface water flow has been diverted, channelized, or culverted
  - Subsurface flow has been converted to surface flow
  - Increased flooding occurs
  - Stormwater management facilities have been installed
- Changes in the sources and transport of sediment. For example, areas where:
  - Active land clearing, construction activities, or agricultural practices occur
  - Sediments are deposited
  - Streams are entrenched
  - There is excessive bank erosion
  - Sediment enters streams from roads and roadside ditches
- Changes in water quality. For example, areas with:
  - Increased input and transport of nutrients (may be associated with sediment sources)
  - Increased input and transport of toxic compounds and pathogens
  - Biological impacts such as closure of shellfish beds or an increase in harmful algal blooms
- Wetlands have disappeared (e.g., from filling or ditching and draining).

Answering this question provides an understanding of how landscape processes and wetland resources have been altered. It is not necessary to measure or quantify changes in landscape processes directly to answer this question. Instead this can be accomplished by comparing maps of the disturbed conditions (generated through the analysis for this question) to the undisturbed conditions as mapped in the analysis needed to answer Question 1. Changes in processes can be inferred from specific indicators of change listed in the bullets above.

For example, the most readily available information on changes in types of land use may be through comparison of historic aerial photographs to current conditions. Such a comparison can illustrate changes such as conversion of forested lands to agricultural or a built condition; conversion of agricultural lands to a built condition; changes in land use from low to high density or residential to commercial/industrial uses; and so on.

Additional data on water quality from monitoring reports, information from surveys of the numbers and types of road crossings on streams and rivers, and/or information on the physical alteration of streams and rivers (ditching, diking, etc.) can all serve as indicators of changes in processes.

## Question 4. What geographic areas are currently important for maintaining landscape processes and can be impacted by future activities and growth?

Once a jurisdiction has identified the areas where landscape processes historically occurred and where they have been changed, it is possible to identify those areas where landscape processes still occur today. This information can be used to predict where additional changes to processes and wetlands might occur from future activities. The purpose is to identify areas where the movement of water, sediment, nutrients, energy, and wildlife are particularly sensitive to additional human activities and disturbances.

The following are some examples of areas that are particularly sensitive to certain types of human activities:

- Filling in floodplains alters the movement of water and especially flood storage. Floodplains are sensitive to filling.
- Paving areas where groundwater is recharged will reduce infiltration and baseflow to streams. Recharge areas are sensitive to paving.
- Building roads through the remaining vegetated corridors will reduce the movement of animals and increase the potential invasion of unwanted plant species. Vegetated corridors are sensitive to being fragmented.

## Question 5. What potential measures are needed to protect and restore landscape processes in order to protect and restore wetlands and their functions?

Answering this question is primarily an analytical process that relies on data and information collected in the previous questions. There are two objectives associated with this question. The first is to identify areas that have not yet been altered but are critical to maintaining processes and functions—the sensitive areas identified in Question 4. These should be managed to minimize the potential impacts of human activities through regulatory and non-regulatory means. The second is to identify where landscape processes have been altered but can be restored. Chapters 6 through 8 of this volume discuss in detail the regulatory and non-regulatory approaches that can be used for protection and restoration.

# 5.5 Questions that Can Be Used to Guide an Analysis of Individual Wetlands

The questions listed below can be used to guide an analysis of individual wetlands. The questions are phrased so the answers can be used to meet both regulatory and non-regulatory needs to protect and manage wetlands. The landscape analysis described in the previous sections is appropriate for the development of land use plans. It does not, however, provide enough detail for making decisions about individual wetlands, either site-specific permit decisions or site-specific decisions about restoration or preservation. Questions 6 and 7 reflect analyses that are usually done during the planning process and in conjunction with the landscape analysis done for Questions 1-5. Question 8 addresses analyses that are most often done when proposals are submitted for altering wetlands.

- **Question 6.** What wetlands are currently performing functions that are associated with important processes identified in the landscape analysis?
- **Question 7.** What degraded wetlands or former wetlands are suitable for restoring landscape processes identified in Question 3?
- **Question 8.** What are the functions of individual wetlands that need to be protected, preserved, or managed?

## Question 6. What wetlands are currently performing functions that are associated with important processes identified in the landscape analysis?

Answering this question is primarily an analytical process that relies on data and information collected in Question 4. The purpose is to identify specific wetlands where the movement of water, sediment, nutrients, energy, and wildlife are particularly sensitive to additional human activities and disturbances. These wetlands will be a subset of the sensitive areas identified in Question 4, and should be highlighted in any general plan to manage and protect wetlands.

For example, headwater wetlands are very important in desynchronizing flood flows in downgradient areas. This desynchronization maintains the landscape process of water flow, and protecting this function in headwater wetlands is important for the entire watershed.

## Question 7. What degraded wetlands or former wetlands are suitable for restoring landscape processes identified in Question 3?

Opportunities for wetland restoration can be identified by developing a map of degraded potential wetlands using hydric soils, wetland inventories, and land use maps. The locations where these former or degraded wetlands intersect the areas where landscape processes occur (from Questions 1 and 4) are the areas best suited for restoration. This information is the basis for developing regional restoration plans, developing mitigation banks, and developing an understanding of the type of compensatory mitigation that is appropriate for permitted alterations to existing wetlands.

## Question 8. What are the functions of individual wetlands that need to be protected, preserved, or managed?

The functions present in a wetland need to be understood in order to apply protective measures, such as buffers, that will adequately protect these functions, or to develop appropriate mitigation plans. Not all wetlands provide the same functions or function at the same levels (see Chapters 2 through 4 in Volume 1 for further discussion). The analysis of functions at individual wetland sites is usually done as part of permitting for actions that could affect wetlands.

In some cases, however, all the wetlands in a basin or sub-basin are analyzed in advance of any actions as part of a regional plan. This information is used to guide planning by identifying up front those wetlands that should not be altered because they perform important functions that cannot be replaced. Wetlands are also identified that do not function well; these can be identified as suitable for development with appropriate compensation. Potential or recommended mitigation sites can also be identified during this planning process. Examples from the Puget Sound area include the Mill Creek Special Area Management Plan or SAMP (U.S. Army Corps of Engineers 1997) and the Everett Snohomish Estuary Wetland Integration Plan or SEWIP (City of Everett 1997).

Most analyses of wetlands at the site scale use rapid approaches that assess a range of wetland functions and values. Many methods have been developed in the last decade to analyze wetland functions and values, and these have been summarized in numerous compilations (e.g. Hruby 1999, Bartoldus 1999, Army Corps of Engineers web information at http://www.wes.army.mil/el/emrrp/emris/emrishelp6/wetland_procedure_descriptions.htm).

Ecology has developed several methods that can be used for the analysis of functions at the site scale. The *Washington State Wetlands Rating Systems for Eastern and Western Washington* were developed to categorize wetlands based on their sensitivity to disturbance, how difficult they may be to replace through compensatory mitigation, the rarity of the wetland type, and the groups of functions they provide.

The *Washington State Wetland Functions Assessment Method* provides more detailed information on up to 15 specific functions that a wetland performs but does not address other values the wetland may provide. It is currently available for a subset of wetland types in both eastern Washington (Hruby et al. 2000) and western Washington (Hruby et al. 1999).

Other methods that have been developed for analyzing individual wetlands in Washington State include the *Wetland Functions Characterization Tool for Linear Projects* from the Washington State Department of Transportation, which characterizes functions as probably present or not present and as principal or secondary functions (Null et al. 2000). A brief description of these and other assessment methods that are often used in the state is provided in Appendix 5-B.